Profile Control of Discharges with Reverse Magnetic Shear on TFTR

Demonstrated control of q profile necessary to improve the stability of Enhanced Reverse Shear regime.

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Presented November 6, 1995 at the
37th Annual Meeting of the
Division of Plasma Physics

Available at http://w3.pppl.gov/tftr

This work supported by the U. S. Department of Energy contract No. DE-AC02-76-CHO-3073.

Why pursue reverse-shear discharges?

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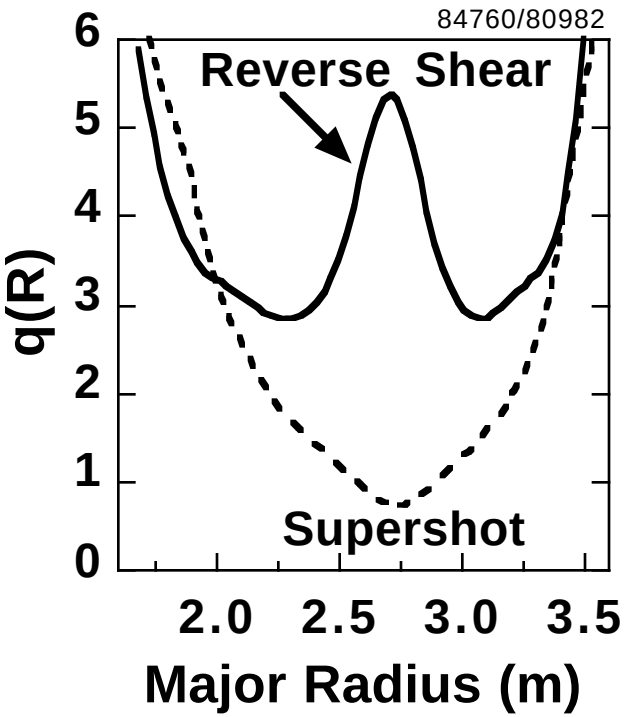
- Reverse shear defined as:

  $s \approx (r/q)\,(dq/dr) < 0$



- Reverse shear predicted to increase stability and to reduce transport

- Reverse shear discharges make transition to "ERS MODE"
  - vastly reduced thermal and particle transport over RS discharges

Heating & NBCD during I_p ramp required to create reverse shear

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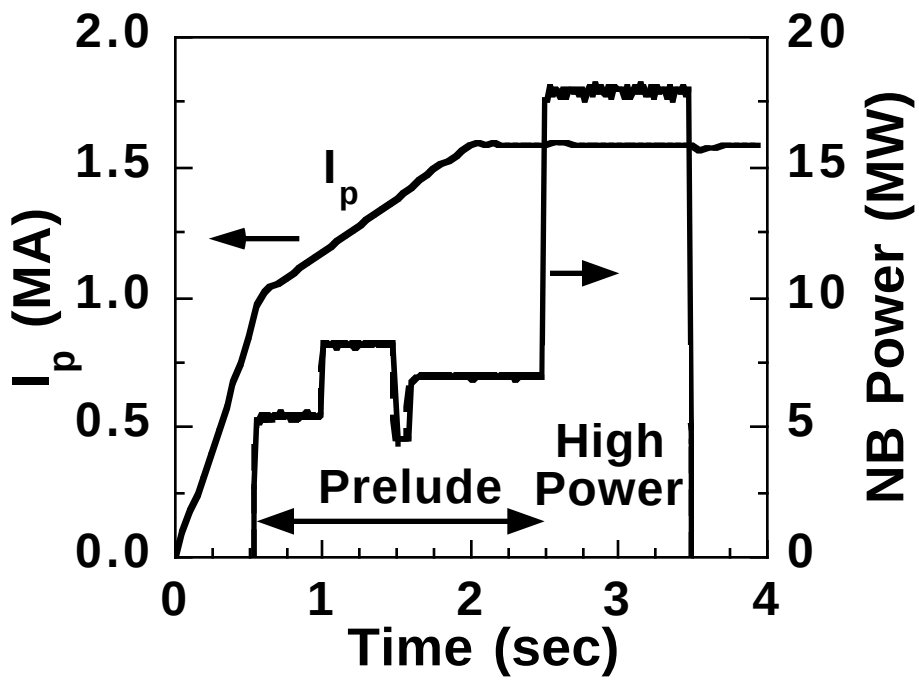
- "Prelude" phase required to create reverse shear
  - co-dominated neutral beam injection

- High-power phase to reach reduced transport regime



Equilibrium reconstructed with free-boundary code (VMEC)

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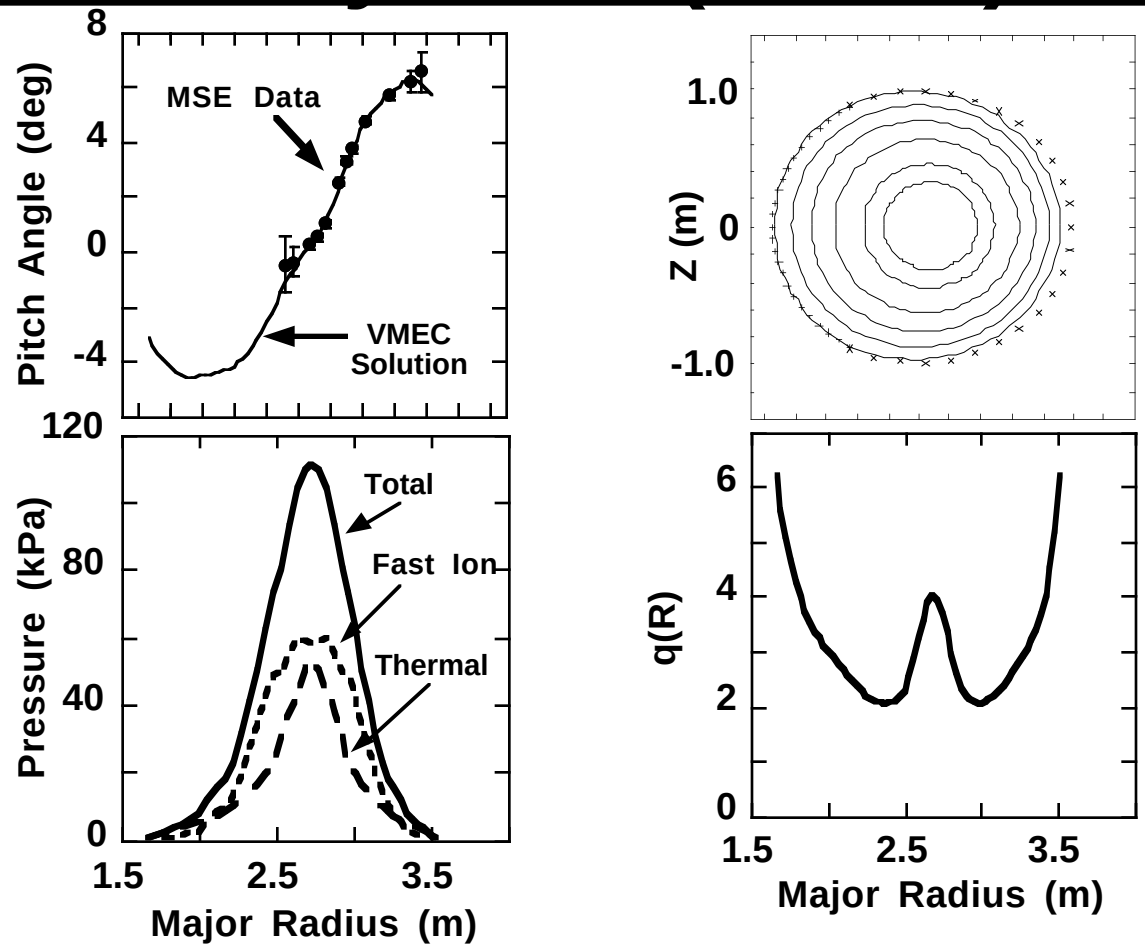

- **Require MSE, calculated total pressure, and usual external magnetics measurements**
- **Code improvements and implementation in TRANSP: posters 5R.31 - 33**

Many q profile control techniques available

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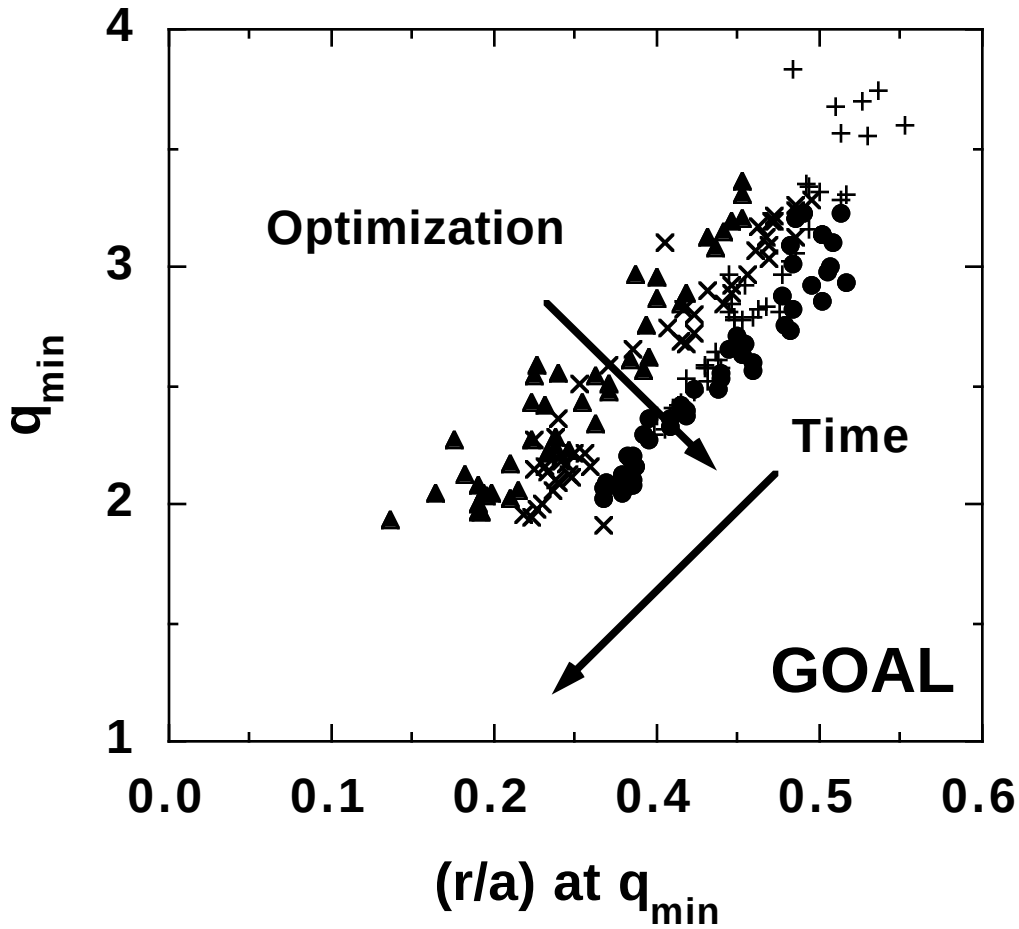
- q_{min} and $(r/a)_{qmin}$ affect stability



- Prelude timing
- NB directionality
- I_p ramp rate

Transition to Enhanced Reverse Shear (ERS) mode

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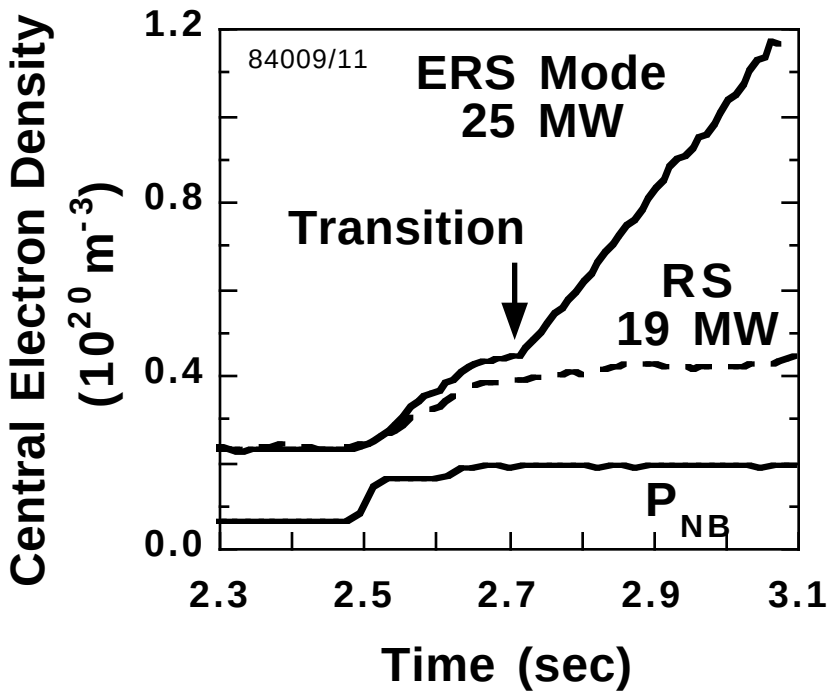
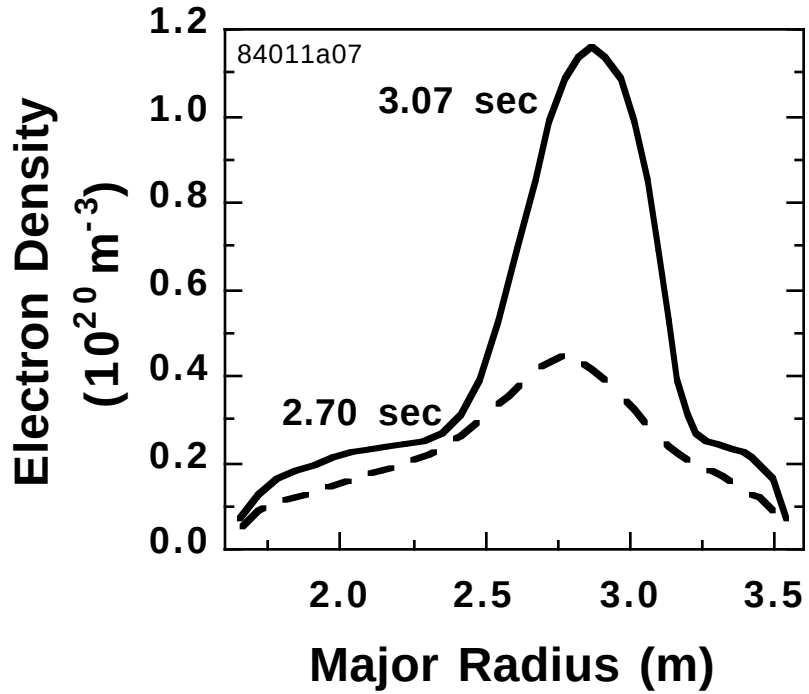
- P_{NB} threshold of 18 - 25 MW
- particle and thermal transport suddenly improve
- enhanced above RS discharge which has low transport
- region correlated with reverse shear region





Particle diffusivity drastically reduced in ERS mode

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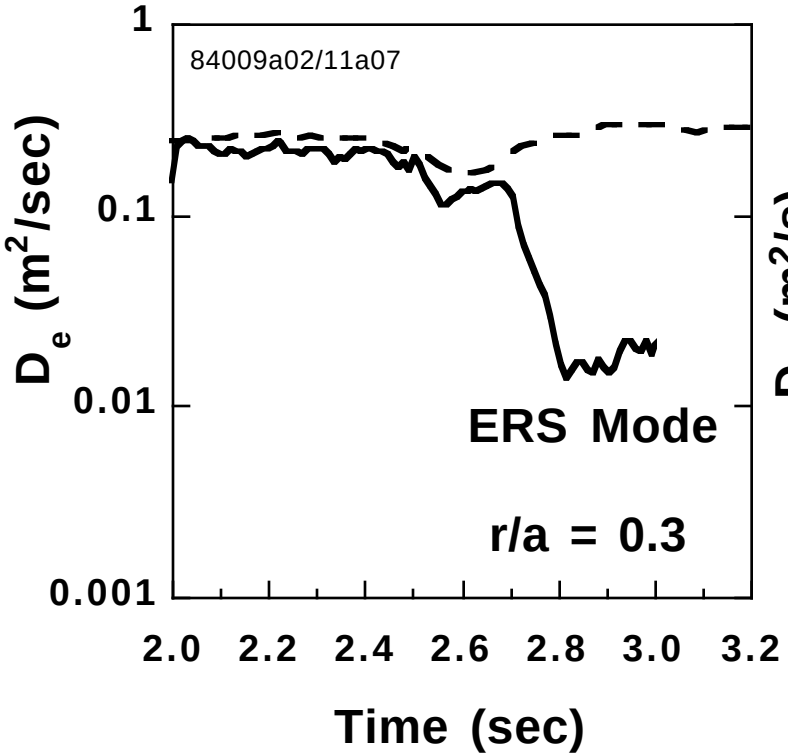

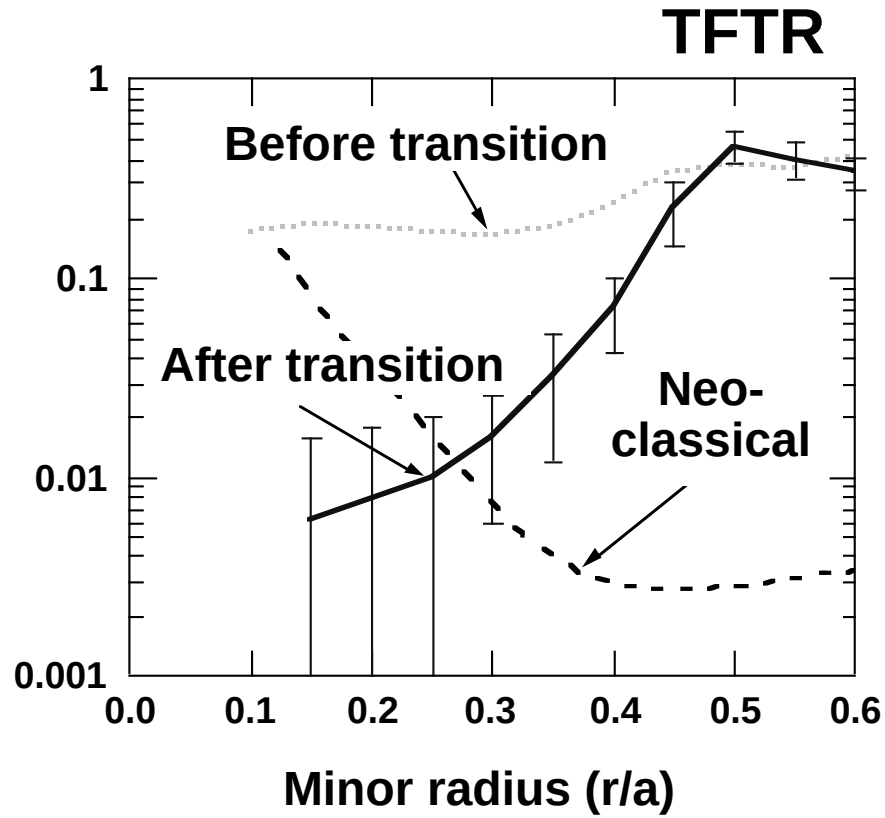

- D_e reduced to neoclassical level in RS region
- No pinch assumed

See: F. Levinton, poster 9P05

Ion thermal diffusivity less than neoclassical

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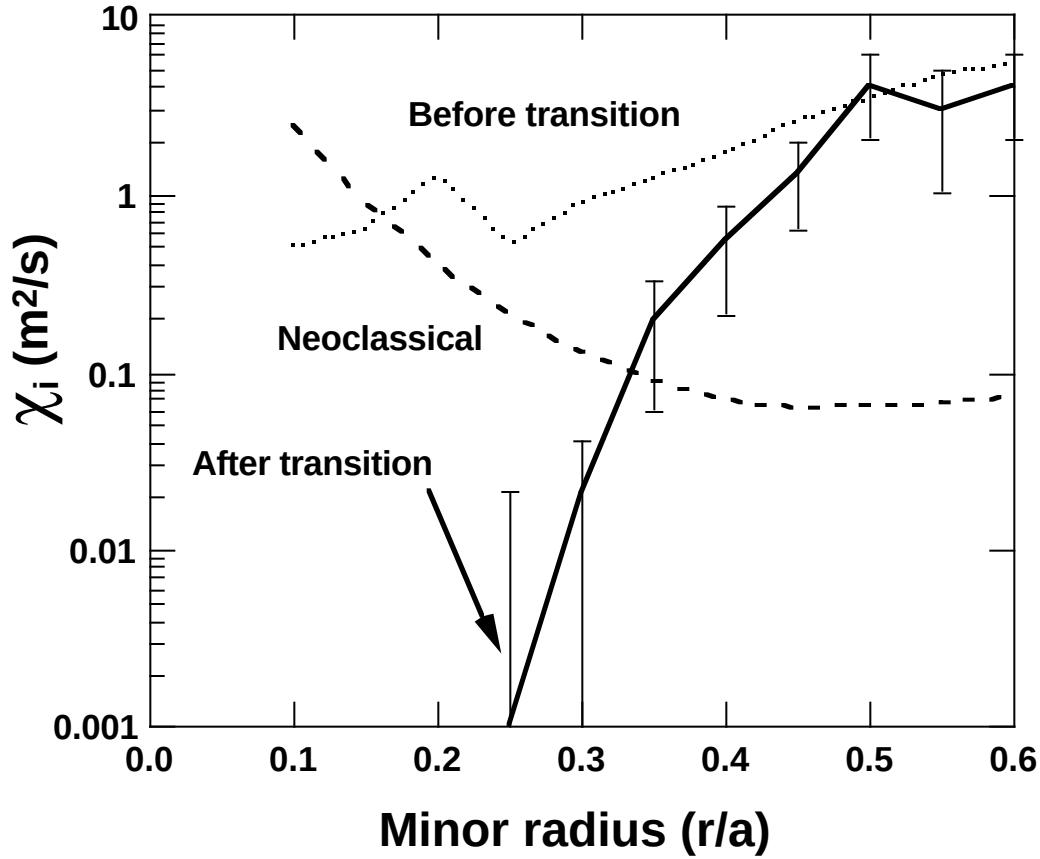

- χ_i reduced below the neoclassical level in RS region
- Classical electron-ion coupling assumed
- No pinch assumed

Conclusions

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- Discharges with reverse shear are produced routinely
- Demonstrated q profile control and optimization
- ERS MODE transition reproducible
- ERS MODE transport vastly improved in core
  - χ_i and D_e at or below neoclassical levels
  - density and pressure peaking

Presentations on TFTR reverse shear plasmas

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Today	M. Redi	2F.11	Ripple
	E. Synakowski	2F.12	Rotation
Wednesday Invited	M. Zarnstorff	8IA.02	Stability & transport
	S. Parker	8IB.03	ITG nonlinear turbulence
Friday	F. Levinton	9P.05	Improved confinement
	G. Schmidt	9P.06	Current evolution
	T. Hender	9P.07	Resistive stability
	J. Manickam	9P.08	MHD stability
	G. Rewoldt	9P.09	Microinstability properties
	E. Mazzucato	9P.10	Turbulent fluctuations
	S. Sabbagh	9P.12	High beta-pol RS
	P. Efthimion	9P.30	Tritium transport
	M. Hughes	9Q.01	MHD stability

Bibliography of TFTR reverse shear experiments

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S. H. Batha et al., "Supershot performance with reverse magnetic shear in TFTR," presented at the 22nd European Physical Society Conference on Controlled Fusion and Plasma Heating, Bournemouth, United Kingdom (European Physics Society, Petit-Lancy, Switzerland, 1995), Vol. II p. 113.

F. M. Levinton et al., "Improved confinement with reversed magnetic shear in TFTR," to be published in Phys. Rev. Lett. (November, 1995).

M. C. Zarnstorff et al., proceedings of this conference, Phys. Plasmas (1996).